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The recent Antarctic explorations have produced a fair number of new Medusæ, many of which have well-marked and interesting specific characters, but there are only about three new genera. Probably, according to Dr. Browne, none of them will remain peculiar to the Antarctic when the ocean has been more thoroughly explored. The littoral Hydromedusæ of the Antarctic have not yet been found in the Magellanic, South Australian and New Zealand areas; it looks as if they belong to an ancient stock which has long been isolated from the rest of the world by the Great Southern Ocean. As evolution is proceeding more slowly in cold than in warm regions, the characters of an Antarctic medusa should be more primitive than those from a warmer sea. Dr. Browne gives comparisons which in a number of cases seem to sustain this view. Some very large scyphomedusæ are reported, including a *Diplulmaris* with arms twelve feet in length.

The lichen material brought back by the expedition included some twenty-five species and there are recorded from the Antarctic continent and closely adjacent islands some eighty-eight lichens. Of these thirty-eight are confined to the region between 60° and 78° south latitude, as far as known. The southern lichens do not present any new genera and occur in small quantities contrasting with the abundance found in the Arctic regions. Four species were found on the peaks of the Antarctic volcanoes, Mts. Erebus and Terror, and of these three are also inhabitants of the Arctic regions. That any indigenous organized object whatever can exist on these gloomy volcanic peaks covered with and rising out of eternal ice and snow, seems almost miraculous!

The plates of this volume are of the usual high quality, and the whole character of the work is such as would be expected from the authorities of the British Museum.

WM. H. DALL

Catalogue of the Lepidoptera Phatænæ in the British Museum. Vol. IX., Noctuidæ, 1910.

The present volume completes the account of the subfamily Acronyctinæ of the Noc-

tuidæ. It contains 725 species in 185 genera, showing a total for the subfamily of 2,288 species in 385 genera. The volumes of this series are appearing with gratifying rapidity. We have only recently noticed the publication of volume VIII. The present volume is on a par with its predecessors in general plan and execution. The table of genera for the subfamily is again repeated with final additions and corrections and will now become fully available.

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SPECIAL ARTICLES

ON THE SPECTRUM OF MARS AS PHOTOGRAPHED WITH HIGH DISPERSION¹

LET us recall that the solar spectrum, as viewed by terrestrial observers, is composite. Photospheric light, in passing out through the gases and vapors of the sun's atmosphere, is selectively absorbed, with the result that many thousands of lines are introduced into the spectrum. The transmitted light passes down through the earth's atmosphere to the observer, and the absorption by water vapor and oxygen in the terrestrial atmosphere introduces many hundreds of additional lines, at definite points in the yellow, orange and red regions. The observed spectrum of the sun is in reality the spectrum of the sun plus the spectrum of the earth. The spectrum of the moon, so far as our present problem is concerned, is simply this sun-earth spectrum.

The light from Mars is photospheric light, which passes out through the sun's atmosphere, thence down through the atmosphere of Mars to the planet's crust, where a certain proportion is reflected out through the Martian atmosphere, and thence down through the earth's atmosphere to the observer. The so-called spectrum of Mars is in reality the sun's spectrum plus Mars's spectrum plus the earth's spectrum.² Any water vapor and

¹ Read at the April, 1910, meeting of the National Academy of Sciences.

² A little of the light would be reflected from the atmospheric strata of various heights without

oxygen in the Martian atmosphere should introduce the same absorption lines which are introduced by the earth's atmosphere in the sun-earth spectrum.

If the distance between Mars and the earth is not changing rapidly, the water vapor and oxygen lines from Mars and the lines from the earth will coincide. When this condition of coincidence exists, it is clearly a difficult problem to detect moderate quantities of water vapor and oxygen in the Martian atmosphere, for the evidence of Martian absorption will be overwhelmed by the absorption of the richly laden terrestrial atmosphere, especially if the observer be near sea level. To hope for success, the observations should be made from a high-altitude station, at times when the overlying air strata carry a minimum of water vapor, and when the planet is as near the zenith as practicable; observing the lunar spectrum, under identical conditions, for comparison.

Because of the faintness of the Martian and lunar spectra, it has been found that we are limited to low dispersion in visual observations: and that when the distance between the two planets is constant or nearly so, low dispersion offers a more sensitive method than high dispersion, even when photography is employed.

Complying with the conditions in the two preceding paragraphs, the writers photographed the spectra of Mars and the moon last September, from the summit of Mt. Whitney. The conclusion drawn from that investigation was, in brief, that the quantity of any water vapor then existing in the equatorial atmosphere of Mars was too small to be detected by the spectrographic methods available. This does not mean that the Martian atmosphere was carrying no water vapor, but only that the quantity must have been very small.

At times other than those when Mars is near opposition, the earth and Mars are relapsing down to the planet's surface. On the other hand, the rays did not, on the present occasion, pass through the planet's atmosphere at right angles to the strata, but the average angle of incidence and reflexion was about 20°.

tively approaching or receding from one another. Their relative velocity at quadrature may amount to 20 km., more or less, per second, depending upon the concurrence of favorable circumstances.

When Mr. Campbell was photographing the spectrum of Mars, in December, 1896, with a Rowland grating, fourth order,³ 568 lines per mm. (14,438 per inch), he realized that the Doppler-Fizeau principle offers great advantages, in theory, for solving the problem of the Martian atmosphere, for on photographs of the spectrum, made near quadrature, with sufficiently high dispersion, the Martian absorption lines and the terrestrial absorption lines should be separated. At that time (thirteen years ago) the method could not succeed, for all the prominent water vapor and oxygen lines are in the region on the red side of $\lambda 5875$, and the photographic dry plates then available were not sufficiently sensitive to record this region. Even in the fairly sensitive region $\lambda 5700$ - $\lambda 5800$ the grating spectrograms of Mars were underexposed. The successes of recent years in sensitizing dry plates to yellow, orange and red light have encouraged the present effort to apply the method.

A spectrograph, designed by Mr. Campbell to meet the requirements of the problem and used in connection with the 36-inch refractor, contains an excellent Michelson five-inch plane grating (15,000 lines per inch) which gives a brilliant spectrum in the second order on one side, and this was utilized. The wooden mounting of the spectrograph was designed at all points to resist differential flexure during the intervals of exposure to the planet and to the moon. The instrument was adjusted, the observations were secured, and the measures and reductions of the spectrograms were all made by Mr. Albrecht.

It was planned to secure observations of Mars and the moon on or near January 17, 1910, as the planet was in quadrature at that time. The spectrographic velocity of Mars with reference to the earth was then 18.8 km. per second, recession. Unfavorable weather

³ *Astrophysical Journal*, 5, 236, 1897.

delayed somewhat the carrying out of the program, but fortunately the velocity remained nearly constant for several weeks, until satisfactory observations were secured.

With the spectrograph adjusted for the orange region, which is rich in water vapor absorption, spectrograms of Mars were secured on January 26 and 27 under poor atmospheric conditions, and on February 2 under excellent conditions, our atmosphere on this night being exceedingly dry. Measures of the available water vapor lines on these spectrograms, 8 to 22 in number, establish that they were displaced with reference to the lines of solar origin in the observed Martian spectrum by amounts on the three dates corresponding to velocities in the line of sight of 19.7, 20.2 and 18.3 km. per second; weighted mean value, 19.2 km. The relative velocities of Mars, computed from our knowledge of the orbits of the earth and Mars, amounted to 19.1 km. per second. The dispersion and slit-width employed were such that the water vapor lines originating in our atmosphere and any originating in Mars's atmosphere should have appeared side by side, though not clearly separated. If the absorptions by the two planets were equal, the two sets of lines of equal intensities should, in effect, have appeared as broad lines of double width, and the measured velocities should have been but half the computed velocities. The facts are that the terrestrial lines were not bordered nor increased in width by companion lines. When the micrometer wire was set successively in the positions which Martian absorption lines would occupy, no traces of absorption were found in these positions. In effect, Martian absorption did not exist to such an extent as to be visible in the spectrum, or to influence the measurements referred to.

With the spectrograph adjusted to the so-called "alpha" region at λ 6280, which includes a large number of oxygen absorption lines, two spectrograms were obtained on February 3. The observable oxygen lines, seven and six in number, were displaced with reference to the lines of solar origin by

amounts corresponding to velocities in the line of sight of 18.8 and 17.4 km. per second. The velocity computed from the elements of the orbits amounted to 19.1 km. The discrepancy of 1.0 km. is within the unavoidable error of measurement. Here again the terrestrial oxygen lines were not bordered nor doubled in width by Martian lines.

The conclusions to be drawn from this investigation are: The quantity of any water vapor existing above unit area in the equatorial atmosphere of Mars was certainly less than one fifth that existing above Mt. Hamilton under the excellent conditions prevailing on February 2. The air temperature was 0° Centigrade, the relative humidity 33 per cent., the absolute humidity 1.9 grams per cubic meter, and the zenith distance 55°.

Likewise, the quantity of oxygen above unit area of Mars must be small in comparison with that in the earth's atmosphere.

It should be repeated that the rays of light utilized had passed in effect twice through the Martian atmosphere.

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SEBASTIAN ALBRECHT

LICK OBSERVATORY,
UNIVERSITY OF CALIFORNIA,
April, 1910

SOCIETIES AND ACADEMIES

THE AMERICAN PHILOSOPHICAL SOCIETY

At the meeting of the American Philosophical Society, on May 20, the following paper was read:

On the Principle of Relativity and its Significance: Dr. ROBERT H. HOUGH, University of Pennsylvania.

The question was considered only in its philosophical aspect. The idea was developed from the fundamental concepts of dynamics as formulated by Newton and Hertz, and extended to the field of electro-dynamics and optics. The validity of the principle as a mathematical concept was maintained. The equations of transformation were derived by purely mathematical steps from two initial equations representing experimental laws to the present probable error of observation: and the consequent relations of the distances and times involved and their respective units considered.